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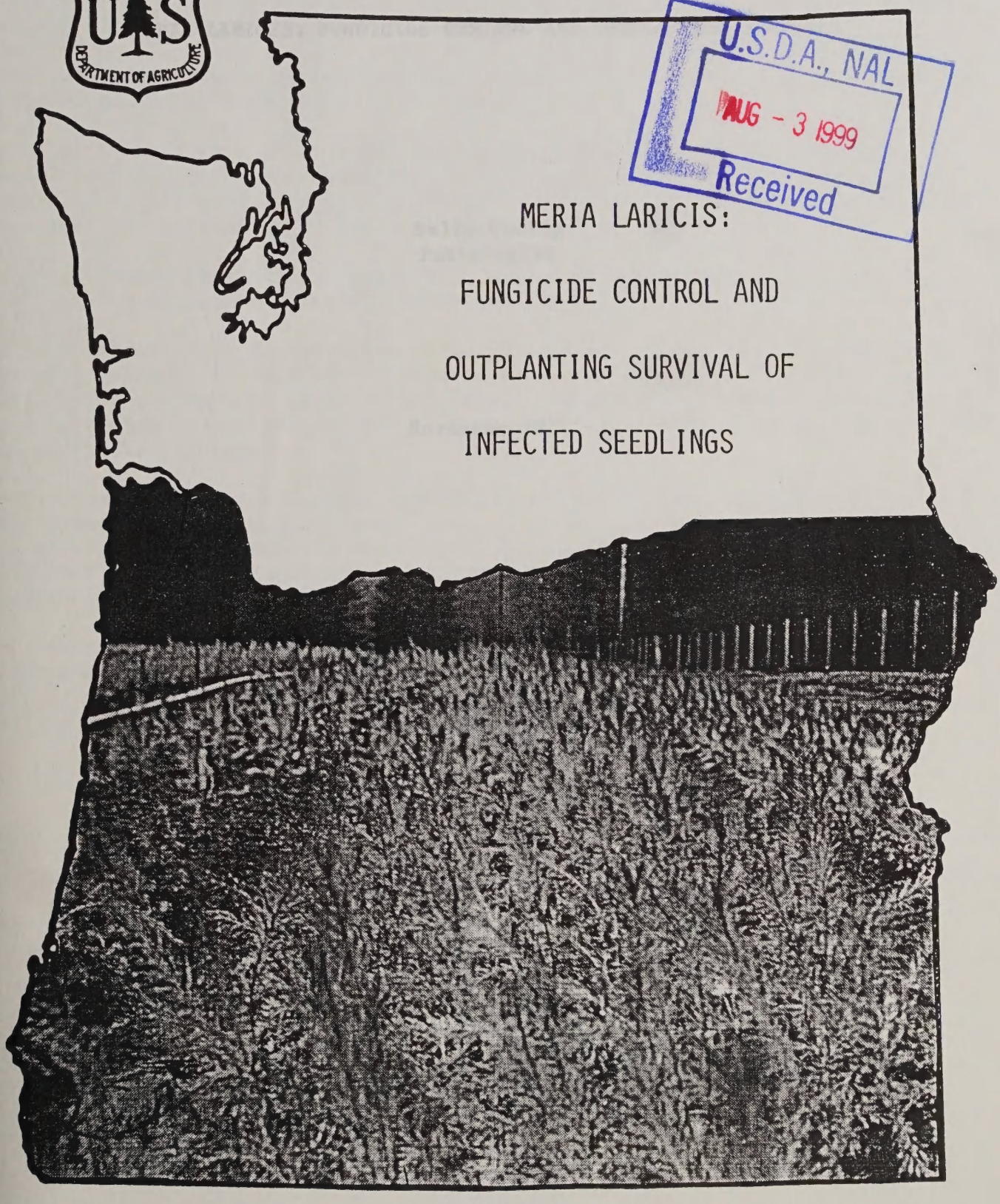
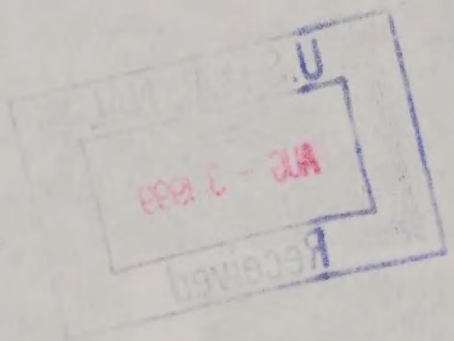
MERIA LARICIS:

FUNGICIDE CONTROL AND

OUTPLANTING SURVIVAL OF

INFECTED SEEDLINGS





MERIA LARICIS: FUNGICIDE CONTROL AND OUTPLANTING SURVIVAL

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PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honeybees or other pollinators are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

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ABSTRACT

Larch needlecast, caused by *Meria laricis*, was reduced by fungicide treatments. Benomyl and maneb appeared to give best protection, followed by ziram, ferbam, and vinclozolin. However, differences among all treatments and no treatment were statistically insignificant. Survival of 150 seedlings from heavily infected nursery beds was 85 percent 3 months after outplanting.

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INTRODUCTION

Western larch, *Larix occidentalis* Nutt., has been grown at the Wind River Forest Nursery since 1976. Production until 1979 has been on a limited basis with less than 75,000 trees sown for annually. In 1979, 140,000 western larch were sown for in Area 4. Needle discoloration and casting were noticed in the spring of 1980 (Figures 1 and 2). *Meria laricis* Vuill., a fungus causing needle casting of several larch species, was identified on affected needles. The biology and history of control of *M. laricis* are discussed in the Appendix (Page 14). It is suspected that infected mature larch in an arboretum adjacent to the nursery is the source of inoculum. By the end of the 1980 growing season, nearly all of the 2-0 larch was infected with *M. laricis* and showing symptoms of the disease, i.e., needle death and needle casting.

Fungicide applications of chlorothalonil (Bravo) were initiated in the late spring of 1980 when a fungus-caused disease was suspected. Weekly or biweekly applications of various formulations of Bravo were made throughout the spring, summer, and early fall. Bravo did not give satisfactory control. Spread of the disease to healthy trees and to new foliage continued throughout the treatment period. Inventory counts during July 1980 showed an average 32.0 percent decrease in stocking due to culling of diseased, dead, or stunted seedlings. The majority of the remaining living trees appeared to be infected as well. It was not known if these living, but infected, trees would survive if outplanted.

Since production of western larch at the Wind River Nursery has increased dramatically (sseds sown for .5 million in 1980 and .375 million in 1981) and will probably remain at these levels or increase, reduction of damage by *M. laricis* and damage assessment are necessary. The objectives of the evaluation described in this report were to: 1. determine what fungicides, if any, will reduce or prevent mortality or heavy defoliation of larch seedlings by *M. laricis*, 2. determine the outplanting survival of infected 2-0 seedlings, and 3. develop management alternatives based on the response to fungicides and field survival.

FIGURE 1. NEEDLE DISCOLORATION CAUSED BY *MERIA LARICIS* ON 2-0 WESTERN LARCH SEEDLINGS

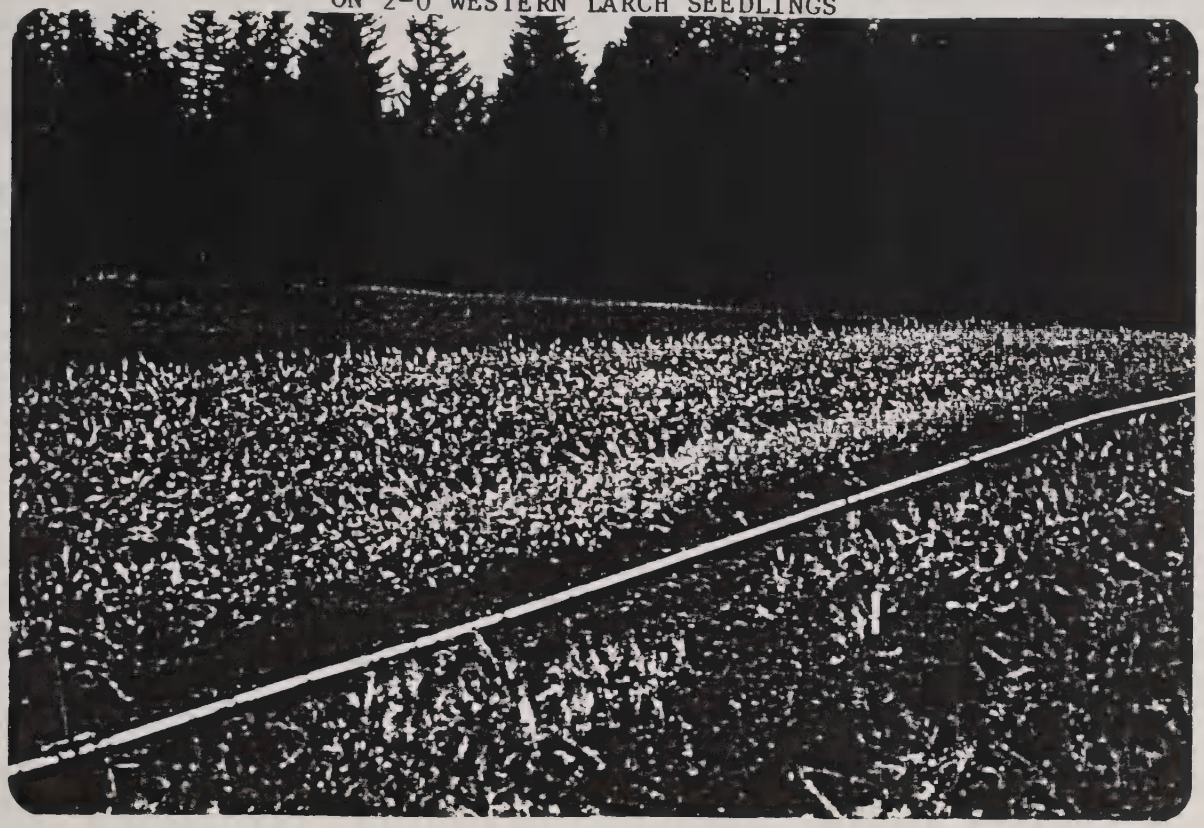
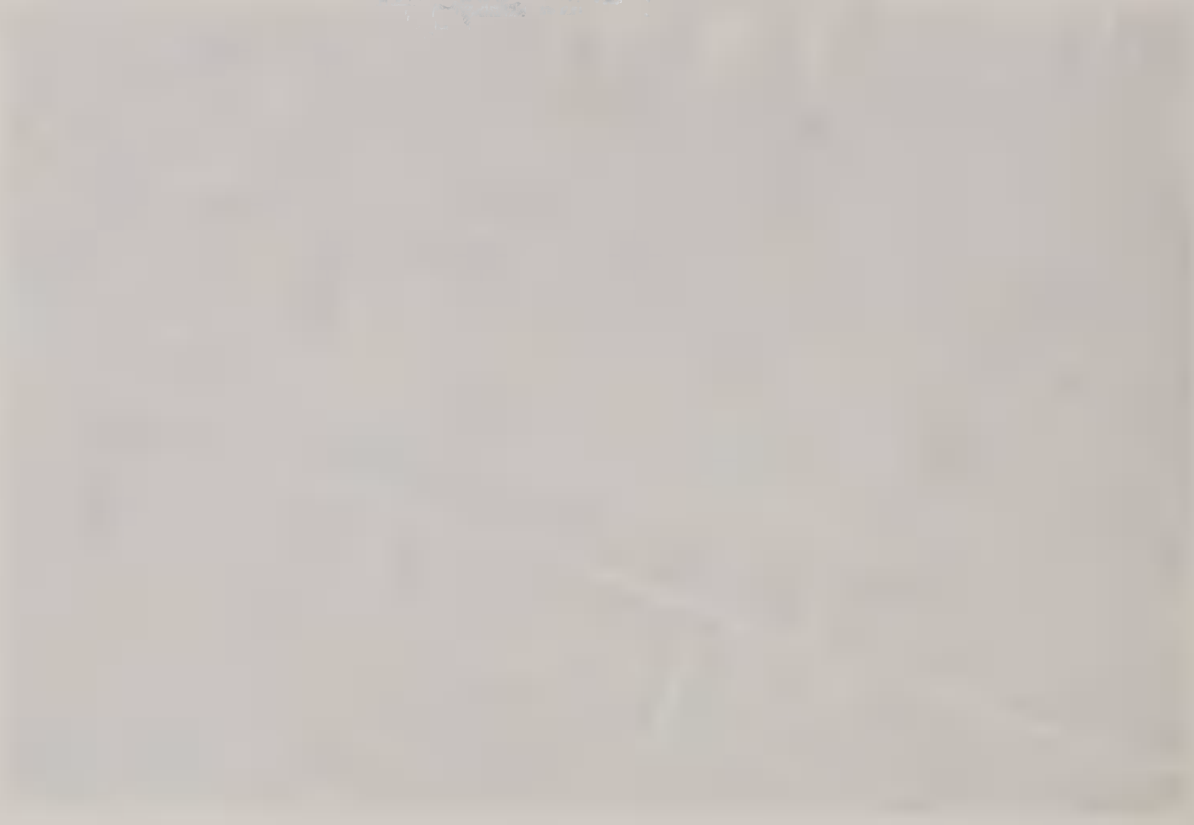
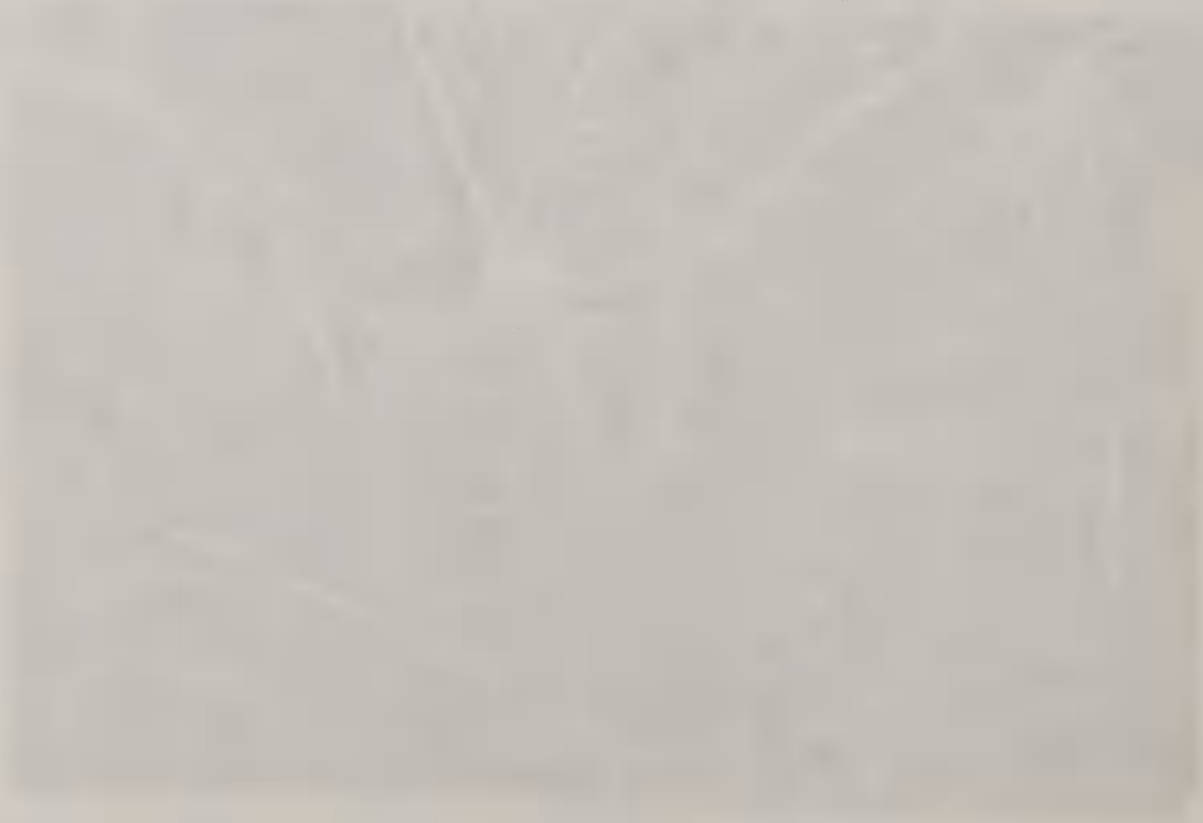


FIGURE 2. NEEDLE CASTING AND MORTALITY CAUSED BY *MERIA LARICIS* ON 2-0 WESTERN LARCH SEEDLINGS





METHODS

1. Fungicide Applications

Five fungicides were selected for field trials on the basis of their ability to inhibit growth of *M. laricis* when grown on fungicide-amended growth media in the laboratory. Fifty parts per million active ingredient of fungicide were incorporated into potato dextrose agar (PDA). A plug from the growing edge of a *M. laricis* colony on nonamended PDA was placed on one edge of a petri plate containing the fungicide-amended PDA. Radial growth of *M. laricis* was measured after 14 days at room temperature. Actual radial growth and growth expressed as a percentage of the control are given in Table 1.

TABLE 1. LABORATORY GROWTH OF *MERIA LARICIS* ON FUNGICIDE - AMENDED POTATO DEXTROSE AGAR. 50 ppm FUNGICIDE USED. GROWTH MEASURED AFTER 14 DAYS ROOM TEMPERATURE.

	Radial Growth[1/] mm	Percent of Check
Check	2.40	100.00
Benlate (benomyl)	0	0.00
Botran (DCNA)	.48	20.00
Captan (captan)	2.20[2/]	91.67
Copper-sulfate	2.14	89.17
Dithane M-22 (maneb)	.08	3.33
Dithane M-45 (mancozeb)	.58	24.17
Dithane M-78 (zineb)	.42	17.50
Daconil 2787 (chlorothalonil)	.62	25.83
Ferbam	.20	8.33
Ronilan (vinclozolin)	0	0.00
Ziram	.15[3/]	6.25

1/ Average of 5 replications.
2/ Average of 3 replications.
3/ Average of 4 replications.

The following fungicides were selected for the field trial: benomyl, maneb, ferbam, vinclozolin, and ziram. Trade names, manufacturers, and rates are given in Table 2.

TABLE 2. FUNGICIDES TESTED TO CONTROL NEEDLE CASTING BY *MERIA LARICIS*

Common Name	Trade Name	Manufacturer	Rate[1/]
Benomyl	Benlate 50 WP	Dupont	1 lb./100 gal. H_2O
Ferbam	Carbamate	FMC	1.5 lb./100 gal. H_2O
Maneb	Dithane M-22	Rohm & Haas	1.5 lb./100 gal. H_2O
Vinclozolin	Ronilan 50 WP	BASF	1.5 lb./100 gal. H_2O
Ziram	Ziram Spray	FMC	1.0 lb./100 gal. H_2O

1/ per 0.5 acre

Fungicides were applied at label recommended rates for foliar diseases to one lot (070-14-863-06000-5.0-2-0-75-SIA) of western larch seedlings in the Bunker Hill South area (Section 17, Beds 2-4).

Treatment plots were 40 square feet (10 feet long by 4 feet wide). Five foot buffer lengths of bed were left between each treatment plot. Three replications of each treatment were made. A randomized block design was employed for plot layout (Figure 3).

FIGURE 3. FUNGICIDE TREATMENT DESIGN

BED 2	CAR-1[1/]	B[2/]	CON-1	B	ZIR-1	B	RON-1	B	DITH-1	B	BEN-1	
BED 3	ZIR-2	B	RON-2	B	CAR-2	B	DITH-2	B	CON-2	B	BEN-2	
BED 4	CAR-3	B	BEN-3	B	DITH-3	B	ZIR-3	B	RON-3	B	CON-3	

1/ CAR = Carbamate (ferbam); CON = control or no treatment; ZIR = Ziram (ziram); RON = Ronilan (vinclozolin); DITH = Dithane M-22 (maneb); BEN = Benlate (benomyl).

2/ B = buffer

The first application of fungicides was made at bud swell (3-6-81). The second and third applications were made approximately 1 (4-13-81) and 2 (5-11-81) months later with subsequent applications at approximate 2-week intervals through July (5-26-81, 6-17-81, 6-30-81, 7-13-81, 7-27-81). Dates of application were dependent on weather since fungicides were not applied in the rain.

Prevention or reduction of disease by *M. laricis* was evaluated by determining the percentage of trees in each treatment plot suffering moderate to heavy defoliation. These percentages were determined by measuring the length of row containing moderately to severely defoliated seedlings, dividing this by the total row length, and multiplying by 100. These measurements were made August 10, 1981, 2 weeks following the final fungicide application (Figure 4).

2. Outplanting Survival of Infected Seedlings

Three plots, each containing fifty 2-0 western larch seedlings from Area 4 (lot 070-14-891-05000-5.0-67) of Wind River Nursery and fifty 2-0 western larch seedlings from Coeur d'Alene Nursery (USDA Forest Service) (lot L-14-4.5-R6-62M) were established in Unit 6 on the Ukiah Ranger District, Umatilla National Forest. Coeur d'Alene seedlings served as uninfected control trees. The seedlings were planted in April 1981. Western larch, Douglas-fir (*Pseudotsuga menziesii*), and ponderosa pine (*Pinus ponderosa*), were planted on the remainder of Unit 6. Natural western larch occurred in the immediate vicinity of the planting site.

FIGURE 4. COLLECTION OF NEEDLE CASTING DATA

Survival of seedlings in the plots was measured on July 21, 1981. If a seedling was dead, an attempt to determine the cause of death was made. Trees with brown or red needles, symptomatic for *M. laricis* infection, were collected and taken back to the lab to determine if *M. laricis* was present on the needles.

RESULTS

Average needle casting was reduced by all fungicide treatments (Figure 5). Average needle casting in three replicated plots was less than 4 percent with applications of benomyl and maneb, 8.7% with ziram, 11.6% with ferbam, 28.5% with vinclozolin, and 52.1% with no fungicide application. However, differences among all treatments (including no treatment) were not statistically significant ($P < .05$).

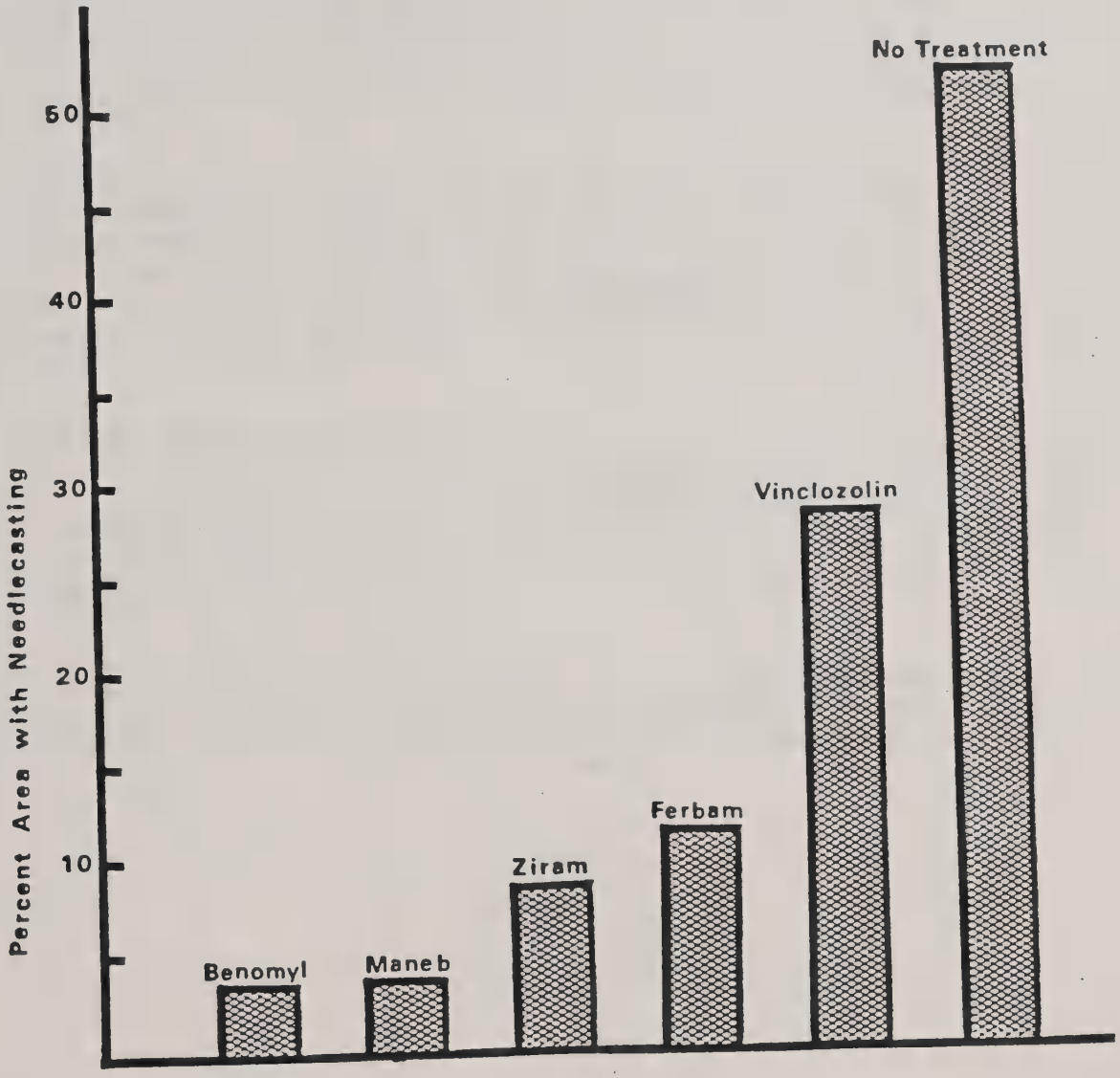
Table 3 compares the survival of larch from the Wind River Nursery which had been heavily infected with *M. laricis* in 1980 to survival of noninfected larch from the Coeur d'Alene Nursery. Average survival of seedlings from infected beds was 85.33 percent; survival of noninfected seedlings was 100.00 percent. Animal damage (browsing or trampling) was responsible for 36 percent of the dead seedlings, insect injury for 5 percent, and no flushing for the remaining 59 percent.

TABLE 3. 1981 SURVIVAL OF OUTPLANTED[1/] WESTERN LARCH ON UMATILLA NATIONAL FOREST, UKIAH RANGER DISTRICT

	Number Alive	Number Dead		
Plot 1		Animal Damage	Insect Damage	No Flush
Wind River	41[2/]	3	1	5
Coeur d'Alene	49	0	0	0
Plot 2				
Wind River	42	3	0	5
Coeur d'Alene	50	0	0	0
Plot 3				
Wind River	45	2	0	3
Coeur d'Alene	50	0	0	0

1/ Planted 4/81
2/ Survival Data Collected 7/21/81

FIGURE 5. PERCENT NEEDLE CASTING CAUSED BY *MARIA LARICIS* IN WESTERN LARCH SEEDLING TREATED WITH FUNGICIDES



DISCUSSION

Fungicide treatments were not significantly different from one another and from no treatment, due probably to high variation of needle casting between replications within some treatments. However, benomyl and maneb gave consistently good control over all replications. Although the effectiveness of maneb has been reported previously (Shonhar, 1958; Shrafranskaya, 1960), no reports of the use or effectiveness of benomyl to control *M. laricis* were found.

Differences between fungicide treatments may have been more dramatic if disease levels had been higher. Infection in 1980 resulted in considerable mortality and very heavy defoliation. Infection in 1981, however, caused no mortality that could be attributed directly to *M. laricis*, and defoliation was much lighter than in 1980.

Heavy and frequent rainfall during the treatment period until July also may have adversely affected fungicide efficacy. The protective period of all the tested fungicides, except benomyl (a systemic), would have been limited to the time between application and the next rainfall when the fungicide would be washed off the foliage. Peace and Holmes (1933) found that fungicide applications were ineffective if applied 4 days after *M. laricis* had been inoculated onto needles.

Survival of the outplanted infected larch from Wind River Nursery seems surprisingly good in light of heavy infection the previous year (1980). It is very probable that trees which did not flush were infected and severely weakened (or killed) the previous year by heavy *M. laricis* defoliation. Trees designated as "no flush" trees represent 9 percent of the total number of Wind River seedlings outplanted in these survival plots.

No definitive explanation can be given for animal damage resulting in death of Wind River stock only and not of Coeur d'Alene seedlings. Wind River seedlings were generally larger than Coeur d'Alene seedlings and may have been less able to tolerate bending or crushing by large animals.

CONCLUSIONS

It appears that western larch seedlings can tolerate some infection by the fungus *Meria laricis* and that the majority of seedlings from heavily infected nursery beds can survive after outplanting, at least in some locations. However, in order to ensure survival, high vigor, and good growth in both the nursery and field, infection by *M. laricis* should be kept at low levels in the nursery. Based on these findings, some options for the management of *M. laricis* in western larch seedlings are given:

1. Avoid high levels of infection by *M. laricis* by growing 1-0 larch crops. If stock can be grown to an acceptable size in 1 year, infection and damage by *M. laricis* will be negligible and there will be no need for fungicide treatments.

2. Transplant larch after 1 year to a new location in the nursery. Cultivate beds from which 1-0 trees are taken so that infected needles (primary source of infection the next year) are turned under. Some disease may be expected the second year from needles remaining on the tree or from other parts of the nursery, but primary infections will be fewer and delayed, and disease levels in 1-1 beds should be lower than in 2-0 beds. Since outplanting survival of infected trees appears to be good, low levels of disease can be tolerated, and fungicides may not be needed the second year.

3. Fungicides can be used throughout the second growing season in 2-0 beds to reduce disease severity. Application of benomyl, maneb, ziram, or ferbam may effectively reduce disease to low or moderate levels if applications are frequent during the cool, moist weather in spring and summer. The first application should be made before needles expand in the spring. The second and third applications should follow 1 and 2 months later with subsequent applications at 2-week intervals. Applications should continue until overhead irrigation ceases and dry, hot weather conditions prevail. If summer is cool with frequent rain, fungicides may have to be applied throughout the summer months.

Low seedling densities would facilitate good coverage of foliage by the fungicide although density is reported to not affect disease development (Peace and Holmes, 1933). If inoculum levels are very high during the second year, fungicide applications may not adequately control *M. laricis*. Although not tested, regular applications of fungicide during the first year may control inoculum build up and prevent high levels of disease the second year.

APPENDIX: BIOLOGY AND CONTROL OF *MERIA LARICIS*

Meria laricis, cause of larch needle cast, is a pathogen on a number of larch species including European (*Larix decidua*), Japanese (*L. leptolepis*), hybrid (*L. eurolepis*), and western larch (*L. occidentalis*) (Batko, 1955; Peace and Homes, 1933).

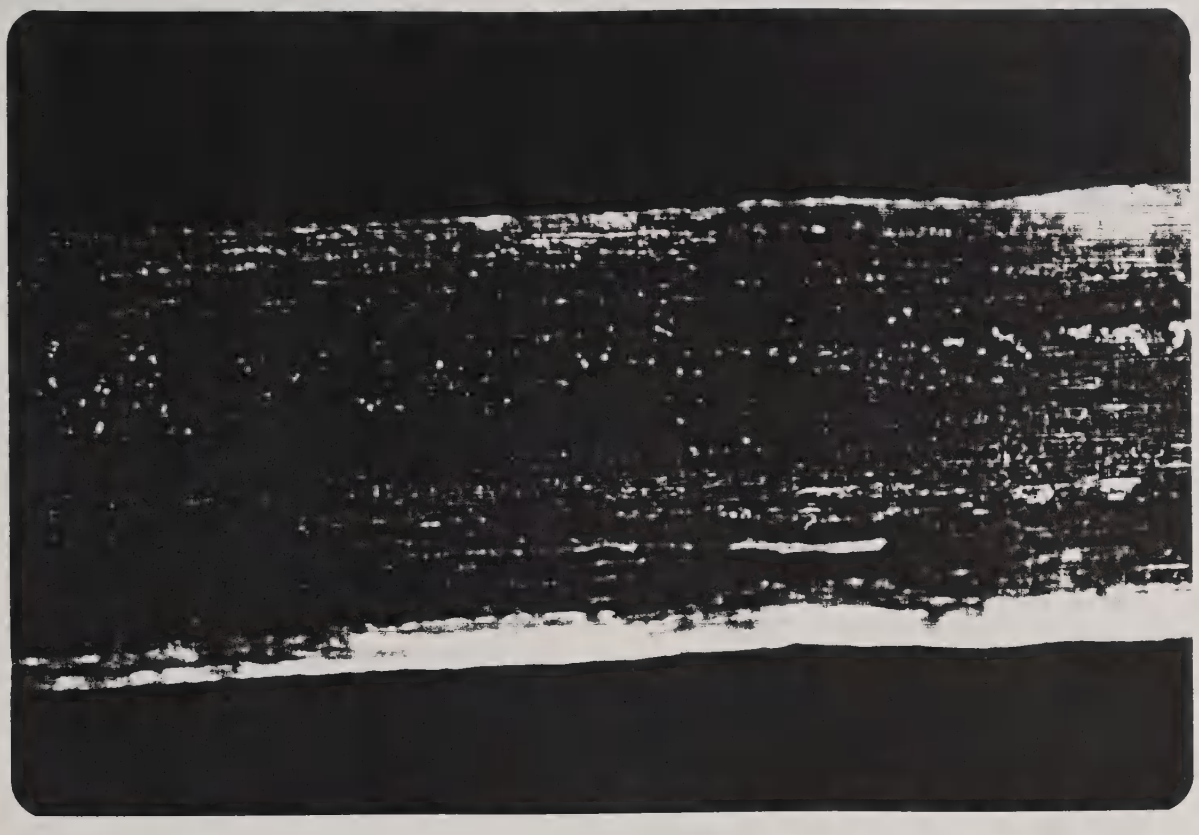
The disease is common in European and North American forests in mature larch but causes little damage (Peace and Holmes, 1933). Infection of young trees or seedlings in nurseries, however, can result in mortality, growth reduction, and weakening of infected trees (Batko, 1955; Aldous; 1972, personal observations, 1980). *Meria laricis* can be introduced into conifer nurseries from infected larch in adjacent stands or from movement of infected seedlings into the nurseries.

Infection by *M. laricis* initially results in a spot or portion of needle becoming discolored and eventually the entire needle will turn brown and be prematurely shed. Infection usually moves from the tip of the needle towards the base. Infections may occur as soon as buds break and needles have expanded in the early spring. Infection can occur throughout the spring and summer under favorable weather conditions (damp and cool to moderate temperatures). Spread of the disease, however generally is halted with the onset of hot, dry weather in the summer (Batko, 1955). Infection can occur in the winter, but growth of the fungus and symptom development are slow (Peace and Holmes, 1933).

Infection is initiated when the germ tube of a spore germinating on the needle surface enters through the stoma (Biggs, 1959). On European larch, infection by *M. laricis* is restricted to leaves less than 4 weeks old (McBride and Hayes, 1979). Asexual spores are produced on the underside and, occasionally, on the upper surface of the needles. Cushion-like masses of hyphae bearing the spores emerge through needle stomata. These spore masses are visible when the needle has been stained with a dye, such as cotton blue or aniline blue, and then observed under low magnification (Figure 6).

Meria laricis overwinters on fallen needles or on needles retained on the tree. Infection the second year arises from spores produced on the old infected needles. For this reason, disease levels are much higher the second year if seedlings remain in the same beds.

FIGURE 6. PORTION OF INFECTED LARCH NEEDLE SHOWING SPORE MASSES (DARK SPOTS) IN STOMATA AFTER STAINING WITH COTTON BLUE DYE



Control of *M. laricis* on larch has been restricted to nursery seedlings. Use of fungicides and cultural modifications have been employed to control *M. laricis* on *Larix decidua* seedlings in European nurseries. Peace and Holmes (1933) recommended use of the sulfur fungicides Amberene (polysulphide), Sulsol (colloidal sulfur), liver of sulfur, or precipitated sulfur from the time of budburst through July. Strong solutions, "winter strength (w.s.)," were applied before buds fully opened and "summer strength (s.s.)" solutions were applied thereafter (e.g., liver of sulfur: w.s. = 14 lb./100 gal. H_2O, s.s. = 7 lb./100 gal. H_2O). One percent lime sulfur solution (Hubert, 1954) and colloidal sulfur (Aldhous, 1972) were reported to be effective against *M. laricis* on *Larix decidua* and *L. leptolepis* in the British Isles. More recent trials with newer fungicides have shown that zineb, bercema-zineb 80, phygon, copper oxychloride, bercema-maneb 80, and captan are effective in controlling *M. laricis* on *Larix decidua* and *L. sibirica* (Ramson et al, 1970; Shafranskaya, 1960; Schonhar, 1958). Use of biological agents also may be a viable means of control in the future. Researchers McBride and Hayes (1979) have shown that certain yeast and bacterial suspensions applied to needles reduce germination of *M. laricis* spores.

Cultural treatments which reduce disease severity generally deal with the removal of the source of inoculum or the removal of seedlings away from high inoculum areas. Aldhous (1972) suggests that individual mature larch trees or larch plantations adjacent to nurseries, often the source of *M. laricis*, may be removed and replaced with other species. Peace and Holmes (1933), Phillips (1963), and Aldhous (1972) recommend that 1-0 seedlings be transplanted to a different part of the nursery to avoid heavy primary infections the following spring by infected cast needles on the ground. Nurseries with no history of Meria leaf cast may avoid introduction of the fungus by raising all larch from seed and avoiding transplanting infected stock from other nurseries (Phillips, 1963).

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